

What is claimed is:

- 5 1. A method for producing a low-extractable film comprising the steps of:
- (a) providing an actinic radiation curable aqueous composition comprising (i) a water soluble compound which contains at least one α,β -ethylenically unsaturated, radiation polymerizable group and (ii) water;
 - (b) applying said aqueous composition onto a surface; and
 - (c) irradiating the surface with actinic radiation in the presence of the water;
- 10 thereby forming a cured film wherein less than 50 ppb of uncured residue is extractable from the cured film when immersed and heated in 10 ml of a simulant liquid per square inch of cured film.

15 2. The method of claim 1 wherein the water soluble compound is an oligomer.

3. The method of claim 2 wherein the oligomer is an acrylate.

20 4. The method of claim 3 wherein the acrylate is selected from the group consisting of a epoxy acrylate, a epoxy methacrylate, a polyether acrylate, a polyether methacrylate, a polyester acrylate, a polyester methacrylate, a polyurethane acrylate, a polyurethane methacrylate, a melamine acrylate, or a melamine methacrylate, a polyethylene glycol diacrylate or a polyethylene glycol dimethacrylate.

25 5. The method of claim 4 wherein the acrylate is an aromatic or aliphatic acrylate.

30 6. The method of claim 4 wherein the acrylate is a diacrylate ester of an alkanolglycidyl ether or an ethoxylated aromatic epoxide or a polyethylene glycol diacrylate.

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7. The method of claim 6 the diacrylate ester of an alkanolglycidyl ether is 1,4-butanedioldiglycidyl ether and the diacrylate ester of an ethoxylated aromatic epoxide.

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8. The method of claim 6 wherein the ethoxylated aromatic epoxide contains 6 to 20 ethoxy groups.

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9. The method of claim 8 wherein water is present in an amount ranging from about 5 weight % to about 25 weight %.

10. The method of claim 8 wherein the composition has a viscosity between 10 and 100,000 centipoises.

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11. The method of claim 1 wherein the composition further comprises a colorant.

12. The method of claim 11 wherein the colorant is a dye, a pigment or a mixture thereof.

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13. The method of claim 1 wherein the irradiating is carried out with high energy electrons.

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12 14. The method of claim 1 wherein the composition further comprises a photoinitiating system activatable by UV radiation.

13 15. The method of claim 14¹² wherein the irradiating is carried out with UV radiation.

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16. The method of claim 1 wherein the substrate is selected from the group consisting of a polyolefin, a polyethylene terephthalate, a metalized polyethylene terephthalate, polycarbonate, cellulosic material, paper material, cardboard

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material, metal, glass, polystrene, polyvinylchloride, polynaphthelene terephthalate, polyacrylate and polyacrylic.

5 17. The method of claim 16 wherein the substrate is a food packaging material

18. The method of claim 17 wherein the food packaging material is a container or a sheet material.

10 19. The method of claim 18 wherein the food packaging material is the polyolefin, the metalized polyethylene terephthalate, the polyethylene terephthalate, or the metal.

15 20. The method of claim 19 wherein the polyolefin is a polyethylene or polypropylene.

21. The method of claim 19 wherein the metal is aluminum foil or steel.

20 22. The method of claim 17 wherein the simulant liquid is a food simulant.

25 23. The method of claim 22 wherein the food simulant is selected from the group consisting of a 10% ethanol/water solution; a 50% ethanol/water solution; a 95% ethanol/water solution; a food oil; a fractionated coconut oil having a boiling range of 240-270°C and composed of saturated C₈ (50-65%) and C₁₀ (30-45%) triglycerides; and a mixture of synthetic C₁₀, C₁₂, and C₁₄ triglycerides.

24. The method of claim 16 wherein the simulant liquid is methylene chloride.

30 25. The method of claim 22 wherein the heating is at least 40°C for at least 240 hours.

23 26. The method of claim ²⁰22 wherein the heating is initially at least about 121°C for 2 hours and then about 40°C for 238 hours.

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27. An improved actinic radiation curable aqueous single fluid composition comprising: a water soluble compound which contains (a) at least one α,β -ethylenically unsaturated, radiation polymerizable group and (b) water; wherein the improvement comprises that when a surface is coated with the composition and exposed to actinic radiation in the presence of the water, a cured film is formed
10 wherein less than 50 ppb of uncured residue is extractable therefrom when immersed and heated in 10 ml of a simulant liquid per square inch of cured film.

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28. The composition of claim ²⁵27 wherein the water soluble compound is an oligomer.

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29. The composition of claim ²⁶28 wherein the oligomer is an acrylate.

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30. The composition of claim ²⁷29 wherein the acrylate is selected from the group consisting of a epoxy acrylate, a epoxy methacrylate, a polyether acrylate, a polyether methacrylate, a polyester acrylate, a polyester methacrylate, a polyurethane acrylate, a polyurethane methacrylate, a melamine acrylate, a melamine methacrylate, a polyethylene glycol diacrylate or a polyethylene glycol dimethacrylate.
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31. The composition of claim ²⁸30 wherein the acrylate is an aromatic or aliphatic acrylate.
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32. The composition of claim ²⁹31 wherein the acrylate is a diacrylate ester of an alkanolglycidyl ether, an ethoxylated aromatic epoxide or a polyethylene glycol diacrylate.
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33. The composition of claim 32 wherein the diacrylate ester of an alkanolglycidyl ether is 1,4-butanedioldiglycidyl ether and the diacrylate ester of an ethoxylated aromatic epoxide.

5 ³¹ ~~32~~ 34. The composition of claim ~~33~~ wherein the ethoxylated aromatic epoxide contains 6 to 20 ethoxy groups.

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10 ~~35. The composition of claim 27 wherein water is present in an amount ranging from about 5 weight % and about 25 weight %.~~

~~36. The composition of claim 27 further comprising a colorant.~~

15 ~~37. The composition of claim 27 wherein the colorant is a dye, a pigment or a mixture thereof.~~

²⁵ ~~34~~ 38. The composition of claim ~~27~~ wherein the actinic radiation is high energy electrons.

20 ²⁵ ~~35~~ 39. The composition of claim ~~27~~ further comprising a photoinitiating system activatable by UV radiation.

³⁵ ~~36~~ 40. The composition of claim ~~39~~ wherein the actinic radiation is UV radiation.

25 ³⁶ ~~37~~ 41. The composition of claim ~~40~~ wherein the surface is selected from the group consisting of a polyolefin, a polyethylene terephthalate, a metalized polyethylene terephthalate, polycarbonate, cellulosic material, paper material, cardboard material, metal, glass, ^{polystyrene} polystyrene, polyvinylchloride, polynaphthelene terephthalate, polyacrylate and polyacrylic.

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30 ³⁷ ~~38~~ 42. The composition of claim ~~41~~ wherein the surface is the polyolefin, or

the metal.

³⁹43. The composition of claim ³⁸42 wherein the polyolefin is a polyethylene or a polypropylene.

5 ⁴³44. The composition of claim ³⁷41 wherein the metal is aluminum or steel.

⁴⁰45. The composition of claim ³⁸42 wherein the simulant liquid is a food simulant.

10 ⁴¹46. The composition of claim ⁴⁰45 wherein the food simulant is selected from the group consisting of a 10% ethanol/water solution; a 50% ethanol/water solution; a 95% ethanol/water solution; a food oil; and a fractionated coconut oil having a boiling range of 240-270°C and composed of saturated C₈ (50-65%) and
15 C₁₀ (30-45%) triglycerides; and a mixture of synthetic C₁₀, C₁₂, and C₁₄ triglycerides.

⁴²47. The composition of claim ⁴⁰45 wherein the food simulant is methylene chloride.

²⁰48. A packaging material comprising a substrate and a cured film adhered to the substrate surface derived by providing an aqueous composition consisting essentially of (a) a water soluble oligomer containing two or more acrylic groups and (b) water; applying the aqueous composition on the substrate; and curing by
25 actinic radiation in the presence of the water, such that less than 50 ppb of oligomer residue is extractable from the cured film when immersed and heated in 10 ml of a simulant liquid per square inch of the cured film.

⁴⁵49. The packaging material of claim ⁴⁴48 wherein the packaging material is a
30 food packaging material and the simulant liquid is a food simulant.

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